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# Osmotic dehydration of eggplant, carrot and beetroot slices: Effect of vacuum on phenolic acid composition

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## *Abstract*

*The aim of this work was to evaluate the influence of vacuum application on the phenolic acid content of osmodehydrated eggplant, carrot and beetroot samples. The contents of catechins and chlorogenic acid were determined by HPLC analysis. Changes in the contents of phenolic acids after the osmotic processes were observed. It was found a reduction in catechins and chlorogenic acids, probable due to the migration and degradation losses. In a general way, the vacuum reduced the catechin and chlorogenic acid contents, compared to the osmotic dehydration at atmospheric pressure.*

***Keywords:*** *Pulsed vacuum osmotic dehydration; chlorogenic acid; catechins.*

## 1. Introduction

The osmotic dehydration (OD) is a technique that provides partial water removal from a food product, with low energy consumption by been carried out at room or moderate temperatures [1]. It is based on the immersion of pieces of fresh fruits or vegetables in a hypertonic solution. The process involves simultaneous counter-current water diffusion from the food to the solution and solute diffusion into the food, under the influence of osmotic pressure gradient [2,3]. It is considered a pretreatment to many processes and preserves physical, chemical and sensorial characteristics of food with few changes on its integrity [4,5].

A mass transfer rate increase can be achieved with the vacuum application in the beggining of the OD, in a process presented as pulsed vacuum osmotic dehydration (PVOD) [6]. The reduction in the pressure causes liberation of the ocluded gases in the pores of the fruit and vegetables making them expelled, due to the action of hydrodynamic mechanisms (HDM) enhanced by pressure difference, increasing the surface area for mass transfer [7–9].

The PVOD process is related to the intensification of water loss and solid uptake, compared with OD. Besides this two mass fluxes, the lixiviation of some nutrients affect qualitatively the nutritional and functional properties of the food subjected to this process [6–8].

As the water is removed, some water soluble constituints, as vitamins and phenolic acids are lixiviated, implying in significative nutritional losses [10]. The vegetables are source of bioactive compounds, among them, the phenolic acids. They confer antioxidant properties and are therefore indicated for the treatment and prevention of cancer, cardiovascular disease and other diseases [11]. This work aimed to evaluate the effect of different vacuum pressures applied in the OD of eggplant, carrot and beetroot slices in the phenolic acid content.

## 2. Materials and Methods

### 2.1 Sample and osmotic solution preparation

Fresh eggplants (*Solanum melongena* L.), carrots (*Daucus carota* L.) and beetroots (*Beta vulgaricus* L.) were purchased in a local market (Lavras, MG, Brazil) and stored in a refrigerator at 8 ± 1 ºC before the experiments.

All of the vegetables were washed with tap water, peeled and sliced (2.00 cm length x 2.00 cm width x 0.40 ± 0.03 cm thickness) using a stainless steel mold. The ternary osmotic solution was prepared with distilled water, sucrose (40 kg 100 $kg^{-1}$ (w/w)) and sodium chloride (10 kg 100 $kg^{-1}$ (w/w)).

## 2.2 Osmotic processes

The osmotic processes were performed in an osmotic dehydrator with temperature and inner pressure control (Fig 1) [8]

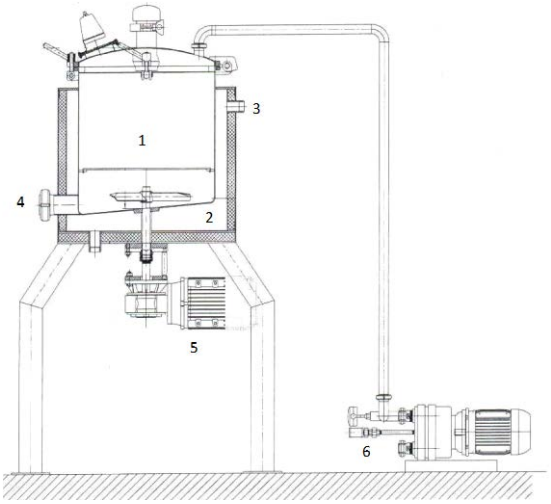


***Fig. 1 Vacuum pulse osmotic dehydration device. 1 - inside osmotic dehydrator, 2 – thermal jack; 3 - outlet of thermal jacked section 4 - output to remove osmotic solution, 5 - motor coupled to the blade inside dehydrator to promote agitation; 6 - vacuum pump.***

The experiments were conducted in three different conditions and the total time of the osmotic process was 300 min. Part of this time, in the beginning of the process (10 min), could involve vacuum pulse application, followed by atmospheric pressure restoration (755 mmHg). The treatments are presented in the Table 1.

***Table 1. Experimental conditions***

| Treatment | Conditions |
|---|---|
| 1 | OD (absolute pressure = 755 mmHg) |
| 2 | PVOD (absolute pressure = 455 mmHg) |
| 3 | PVOD (absolute pressure = 155 mmHg) |

The processes temperature was set at 35 ± 1 ºC and the ratio of solution to vegetable was 1:10 (w/w). After the osmotic processes, the samples were removed from the solution and immersed in a bath of cold distilled water during 10 s to stop the osmosis and to remove

solution excess. The surface of the samples was gently wiped with absorbent paper, and they were weighed and submitted to moisture content determination [12] and cromatography analyzes. All the experiments were performed in four replicates.

## 2.3 Chromatography analyses

The polyphenols for high performance liquid efficiency chromatography (HPLC) were extracted using 2.5 g of pulp and 20 mL solution containing 70% methanol in water (v/v) [13]. Briefly, the samples were homogenized and placed in an ultrasonic bath at 20 ºC for 60 min. The extracts were centrifuged at 1400 g for 15 min at 4 ºC and filtered through Whatman nº 2 filter paper. The extracts were again filtered with regenerated cellulose filters 0.45 μm (Millipore, Bedford, MA, USA) and stored at −18 °C until the analyses.

The chromatographic analyses were performed using an Ascentis C18 5-lm (250 mm x 4 mm) column. The mobile phase consisted of 2% (v/v) acetic acid in water (mobile phase A) and 70:28:2 methanol/water/acetic acid (mobile phase B), set to a flow rate of 1.0 mL min-1 and conducted using a gradient elution programme and a 65 min run time. The injection volume was 20 μL. Analyses were performed at 15 ºC. The phenolic compounds generated a UV–Vis spectral result in the HPLC chromatogram at 280 nm. Quantitative determination of compounds was conducted by comparison with dose–response curves based on *m/z* data from authentic standards of individual polyphenols [14]. The results of three replicates were expressed as mg 100 $g^{-1}$ (d. b.).

## 2.4 Statistical analyses

The results were subjected to analysis of variance (ANOVA) using software STATISTICA 8.0® (Statsoft, Tulsa, USA). Tukey's test was used to compare means at the 5% significance level ($p < 0.05$).

## 3. Results and discussion

For the identified phenolic acids, significant differences after the osmotic processes ($p \leq 0.05$) have been found (Table 2) for all the vegetables.

According to the Table 2, catechin was identified in all the different vegetables, with higher concentration in beetroot samples, followed by carrot and eggplant. The chlorogenic acid (5-O-caffeoyl-quinic acid; CQA) was observed only in the eggplant samples.

A reduction in the catechin content was observed for all osmodehydrated vegetables (Table 2). This occurred probable due to the migration and lixiviation losses, that are related with

the mass transfer during the osmotic dehydration. It is well known that as the water is removed from the products (due to the osmotic pressure gradient between the material and the osmotic solution), some water soluble compounds also migrate from the cell tissue to the liquid media [15–17]. For the beetroot samples, the catechins were lightly preserved in the treatment 2 (PVOD with absolute pressure of 455 mmHg) (Table 2).

***Table 2. Phenolic acid content of fresh and osmodehydrated vegetables [mg 100 g$^{-1}$] (d.b.)***

| **Treatments** | **Fresh** | **1** | **2** | **3** |
|---|---|---|---|---|
| | | Catechin | | |
| Eggplant | 21.26±1.66$^{a}$ | 12.22±1.24$^{b}$ | 13.42±0.61$^{b}$ | 2.40±0.15$^{c}$ |
| Carrot | 36.89±2.89$^{a}$ | 28.72±1.44$^{b}$ | 31.42±2.06$^{b}$ | 21.09±0.10$^{c}$ |
| Beetroot | 215.48±4.31$^{a}$ | 90.17±3.93$^{c}$ | 116.67±4.20$^{b}$ | 75.17±2.88$^{d}$ |
| | | Chlorogenic acid | | |
| Eggplant | 367.71±11.43$^{a}$ | 219.07±11.42$^{b}$ | 183.17±8.29$^{c}$ | 82.92±3.62$^{d}$ |

*Average value ± standard deviation. Mean followed by different letters in the row differs significantly ($p < 0.05$), according to Tukey's test.*

Comparing the catechin content in fresh and osmodehydrated blueberries [18] also observed significant reduction in its retention. They concluded that the vacuum application reduced the catechin content, compared with OD treatment.

Studies indicate that the main phenolic compound in the eggplant is the chlorogenic acid [19]. Its content was reduced in PVOD treatments by 50-75 % (Table 2). This phenolic compound is a hydroxycinnamic acid derivative, and such a reduction occured probable due to the mass transfer intensification when the vacuum was applied [20-22]. Nevertheless, the losses of this polyphenol acid was also observed in OD treatment. This indicates that besides the losses by lixiviation, some oxidative and hydrolytic modifications were observed.

According to the Table 2, the vacuum application implied in a pronounced phenolic reduction, compared to the OD. The retention in phenolic compounds are desirable, once they present a wide range of biological activities, related to the risk decrease of heart and neurodegenerative diseases, and certain forms of cancers [23].

## 4. Conclusions

The osmotic dehydration of vegetables (eggplant, carrot and beetroot) was achieved in different conditions. It was observed changes in the phenolic acid contents after the osmotic processes. It was found a reduction in catechins and chlorogenic acids, probable due to the migration and degradation losses. In a general way, the vacuum reduced the catechin and chlorogenic acid contents, compared to the OD. It was concluded that the osmotic process (under vacuum or atmospheric pressure) reduces the analyzed phenolic acid content.

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